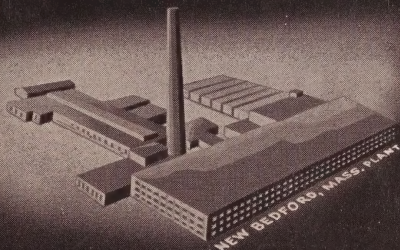
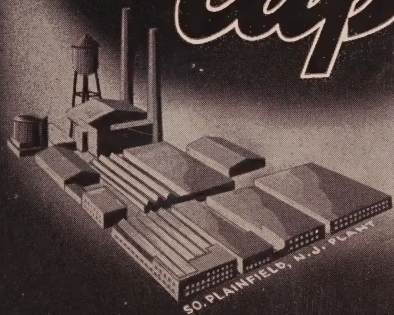


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PHASE INVERTERS*

Articles on phase inverter circuits which appeared in the radio press in the past have created considerable interest among many C-D Capacitor readers, and for this reason the following discussion should prove to be of further interest on this subject.

This article gives a thorough discussion of the design and operation of many types of phase inverters. Most of the circuits discussed are widely used while others are quite novel in operation.

The grid excitation requirements of a push-pull audio amplifier are such that it is necessary to excite each grid, or bank of grids, with the same amount of audio voltage, but the voltage on one side of the balanced amplifier must be opposite in phase to that on the other side of the amplifier, if the voltages from each side of the amplifier are to mix properly in the plate transformer. That is, the voltage applied to one grid or bank of grids, must reach its positive peak in the a.c. cycle at the same instant that the voltage applied to the other grid or bank of grids reaches its negative peak in the a.c. cycle.

A brief glance at the action of the output transformer will reveal why this action is necessary. If the grid voltages were in phase, the plate current through the two tubes would rise or drop simultaneously, and their effects would cancel in the output transformer, resulting in no output. However, if the grid voltages were 180° out of phase, the current in one tube would be rising while that in the other tube would be falling, with the result that the induced voltage in the secondary of the output transformer would be twice that for one tube.

A good interstage transformer, with a center-tapped secondary, is the simplest and best method of obtaining this excitation voltage, since the voltages at the opposite ends of this secondary winding are 180° out of phase. How-

ever, good transformers are too expensive, as well as too large, for use in the modern midget receivers and the low powered sound systems and, since the coming of high fidelity transmissions some ten or twelve years ago, most manufacturers have reverted to resistance-coupled phase inversion. This electronic method of satisfying the excitation requirements of push-pull audio amplifiers was chosen for several reasons. The fidelity of the resistance-coupled phase inverter is as good as, if not better than, that of most transformers. The space that a phase inverter consumes is only one-third to one-half as great as that of a transformer. The original cost is a great deal less, since it is made up of a tube and a few inexpensive resistors and condensers whose electrical values are not too critical. Furthermore, it is possible to attain a higher frequency response and, in some circuits, a higher voltage step-up than it is possible to get from low price interstage transformers. A good transformer has the advantage that it has much higher inherent stability than the phase inverter and, for this reason, it is used in commercial communications work. Another advantage of a good transformer is that the impedance in the grid circuits following the driver can be high while the d.c. resistance can be kept low, and this condition is almost necessary in the case of a class-A prime amplifier where grid current flows over a portion of the cycle. It is

* By Harold A. Bustard in "Radio News."

necessary to keep the next stage grid resistors comparatively high when using a phase inverter, in order to prevent loading of the inverter, which would cause unbalance because of changes in the excitation voltage to the inverter tube grid. Also, it would seriously impair the frequency response at the higher frequencies.

The purpose of the phase inverter, then, is to provide two voltages which

One of the first phase inversion systems ever used was of this type and is shown in Fig. 1. Two resistors, R_3 and R_4 , are connected in series across the first half of the output transformer primary. The grid voltage for the second output tube is taken from the junction of these two resistors and fed to the grid of the second tube through coupling condenser C_2 whose value is generally $.01 \mu\text{fd.}$ and is al-

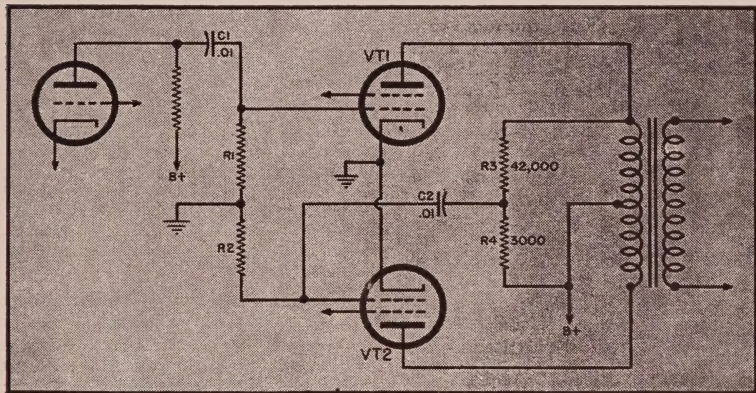


Fig. 1. Phase inversion takes place in the output stage. This system has the advantage of not requiring an inverter tube or additional transformers.

are equal in magnitude and 180° out of phase, which can be utilized to drive a push-pull amplifier. There are numerous methods of accomplishing this but the basis of operation of the majority of the systems is that a small portion of the output voltage from either the driver stage or the output stage is coupled to a similar driver tube, or to the grid of the other output tube, through a suitable coupling arrangement to provide the necessary excitation voltage for the push-pull tubes.

The systems where the phase inversion takes place in the output stage itself are perhaps the most simple and are all adaptable for use in the service shop where it is necessary to get around shortages of inverter tubes and transformers.

ways the same as that of C_1 . When first looking at the circuit, it is difficult to see how such an arrangement can satisfy the requirements of a phase inverter. However, the voltage developed across R_3 and R_4 is 180° out of phase with that developed across R_1 , because of the 180° phase shift in V_1 , and the sizes of R_3 and R_4 are adjusted so that the magnitude of the voltage fed to the grid of V_2 is the same as that appearing at the grid of V_1 . Thus, the two grid voltages are equal in magnitude and 180° out of phase. In Fig. 1, it is assumed that V_1 has a gain of 15, so R_3 and R_4 are so proportioned that one-fifteenth of the output voltage of V_1 is fed to V_2 .

Other values of resistors could be used proportionately. However, we

find that if the total resistance is very far below a critical value of fifty thousand ohms, the transformer will be loaded with a resultant reduction in power and fidelity, while, if the total resistance is much higher, the balance will be affected on high frequencies due to the effects of stray capacities in wiring, transformer distributed capacities, and the output and input capacities of the tubes. The values of R_1 and R_2 are standard for the type of tubes used and, of course, they should both have the same value. The parts values are not very critical, and, as in the case of most electronic equipment, a tolerance of ten per cent is allowable which gives one a chance to use standard replacement parts if the exact size is not available. The small mismatch that could be caused with this tolerance is easily balanced out in the output transformer with no ill effects other than a slight reduction in the output voltage, which will be less than five volts in most cases. This circuit is almost entirely independent of tube characteristics in that, if the excitation voltage to VT_1 drops or if the emission in VT_1 drops, there will be a similar reduction in the voltage drop across

R_1 . Therefore, the excitation voltage to VT_2 will be reduced accordingly. Under these conditions, only the characteristics of VT_2 can really greatly affect the fidelity of the amplifier.

The circuit has the definite advantage that it is simple and uses only the regular output tubes, so no additional space is consumed. Its disadvantages are slight and may be neglected in most receivers; the resistors across the transformer primary have a loading effect on the transformer, regardless of their value, and they take part of the power off of the first half of the transformer. This loading effect reduces the output slightly (less than ten per cent) and hinders the fidelity. It seems to flatten the high frequencies and the cut-off point for low frequencies is around 100 c.p.s. The circuit is however, adaptable to all types of output tubes, whether they are triodes, pentodes, or tetrodes.

In Fig. 2, we have a similar circuit, but here we have taken advantage of the changes in the screen grid current which are similar to the plate current changes and we have placed a resistor

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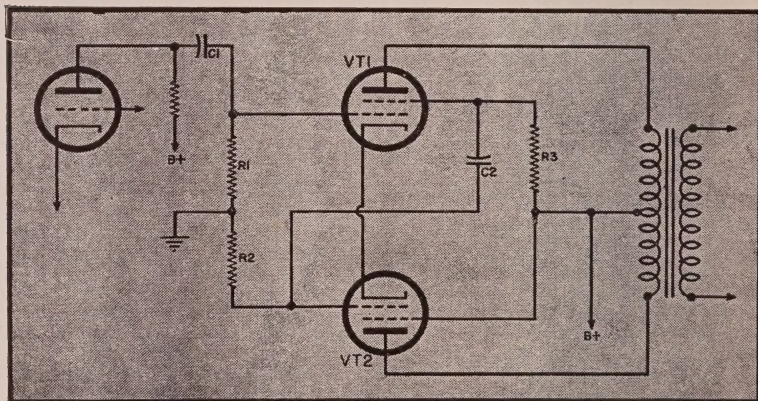


Fig. 2. Similar in operation to Fig. 1, with the exception that advantage is taken of changes in the screen grid current in order to obtain phase inversion.



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FOR SALE—Number of radio theory and Electrical books in like new condition. Send for list. S. S. Schlissel, 3957 Gouverneur Avenue, New York 63, N. Y.

FOR SALE—Superior mod. 1130-S generator from 100 kc to 105 mc and 100 to 7500 cycles audio, audio not working. Several home made meters; old Hickok tube tester, 25v range. Make offer. John E. Thiel, 1003 No. Denver, Tulsa, Okla.

TRADE—General Electric FP 265 oscillator or RF amplifier 200 w. for good Weston 200 microamp meter. P. J. Rumbol, 46 N. High St., Greenville, Pa.

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WANTED—4 6N6G tubes or 6B5 or pair of each. Schematic diagram for mod. 307 dependable tube tester, Radio City Product and instruction. Grant La Maye, 548 E. 6th St., 2nd floor, Erie, Penna.

FOR SALE—Zenith car radio for 1941 Ford, excel. cond. except for roto selector, mod. 6 MF 590, \$25. C.O.D. Will trade for Philco table model 604. Grant La Maye, 548 E. 6th St., 2nd floor, Erie, Pa.

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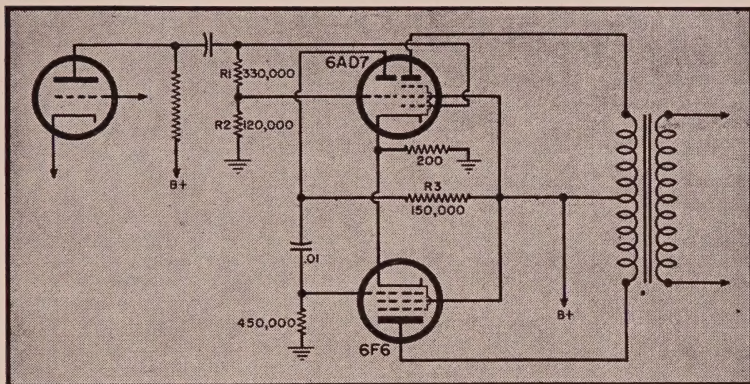


Fig. 3. A 6AD7 triode-pentode is used as an output tube. The pentode section is used for push-pull operation and the triode section is used as an inverter.

(Continued from page 4)

in the screen grid circuit of VT_1 . The voltage drop across this resistor is 180° out of phase with the input voltage and is proper for the excitation of VT_2 . The value of resistor used depends, of course, on the tubes used. Each tube, of course, has slightly different screen grid current variations when the tube is working. What is meant is that the screen current in one tube may rise from 10 ma., no signal value, to 15 ma., peak signal value, while another type may have a 20 ma. no signal value, and will rise to 40 ma. on peaks. This information can usually be found in the manufacturers' data, as can the following necessary conditions. The peak grid voltage necessary for the tube to work at full output is usually equal to the manufacturers' grid bias voltage rating. The peak a.c. voltage drop across R_3 will be equal to this grid voltage. The exact value of resistor R_3 can then be calculated from Ohm's law, remembering that the changes in current corresponding to the audio signal will be the only current changes that will develop an a.c. voltage which is needed. Therefore, if the manufacturers' data shows the no signal current as 10 ma. and the peak current as 15 ma., the

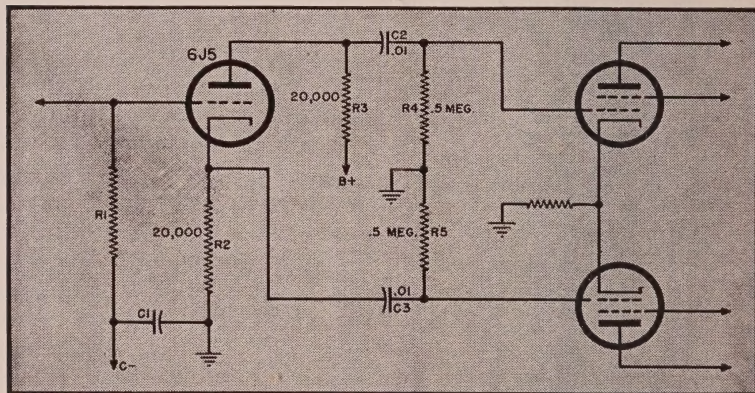
difference between the two will be the value to use in calculating the value of R_3 .

In the event that you cannot find this data, approximate values of R_3 for the two popular classes of output pentodes and tetrodes are for 41, 6K6, 7B5, and others requiring high excitation values on the order of twenty volts, use a resistor of 3800 to 4000 ohms. For tubes such as the 42, 6F6, 6V6, and 7C5 whose amplification factor is higher and grid voltage lower, a resistor of 3500 ohms will be found to work satisfactorily.

As in the case of all push-pull amplifiers, any small amount of unbalance will be unnoticeable, since it will be balanced out in the output transformer at a slight loss of power. Small differences may be made up by proper choice of coupling condensers, but this is slightly out of the technician's field and, as differences in coupling condenser values also tend to reduce the fidelity of the amplifier, it is suggested that small unbalances be left up to the output transformer which will take care of them very adequately.

Another method of phase inversion in the output stage is shown in Fig. 3. In this circuit, a 6AD7 triode-pen-

In Fig. 4, we have what is probably the simplest of these inverter-driver systems. A simple triode such as a 6C5, 6J5, or 76 is used. The plate and



cathode resistors are made equal. When a signal is applied to the grid of the tube, over the positive half of the a.c. cycle, the current in both resistors, R_2 and R_3 , increases. This increase in current naturally causes an

increase in voltage drop across these resistors. As a result, the voltage at the plate of the tube becomes more negative with respect to ground and the voltage at the cathode becomes more positive with respect to ground. When the two resistors are of equal value, the peak negative voltage at the plate is equal to the peak positive voltage at the cathode. Since these two voltages are of opposite polarity, or, in other words, they are 180 degrees out of phase, they may be utilized to drive a push-pull amplifier.

The exact values of resistors R_2 and R_3 are not very critical and any value from twenty thousand ohms upwards to fifty thousand ohms is satisfactory as long as both values are the same,

the higher value giving slightly higher output voltage. The circuit could also be adapted to the high gain type triodes such as a 6F5, 6SF5, 6SQ7, etc., but the plate resistance of these tubes is so much higher that, in order to keep the plate resistor values above the plate resistance value a sufficient amount to keep the operation linear, the resistor values would be in the 100,000 ohm class with the result that the small amount of plate current in these tubes would be reduced nearly to zero.

The circuit has the advantage that it is simple. It is also entirely free from the effects of tube emission changes, since a change in the current in one resistor will likewise affect the

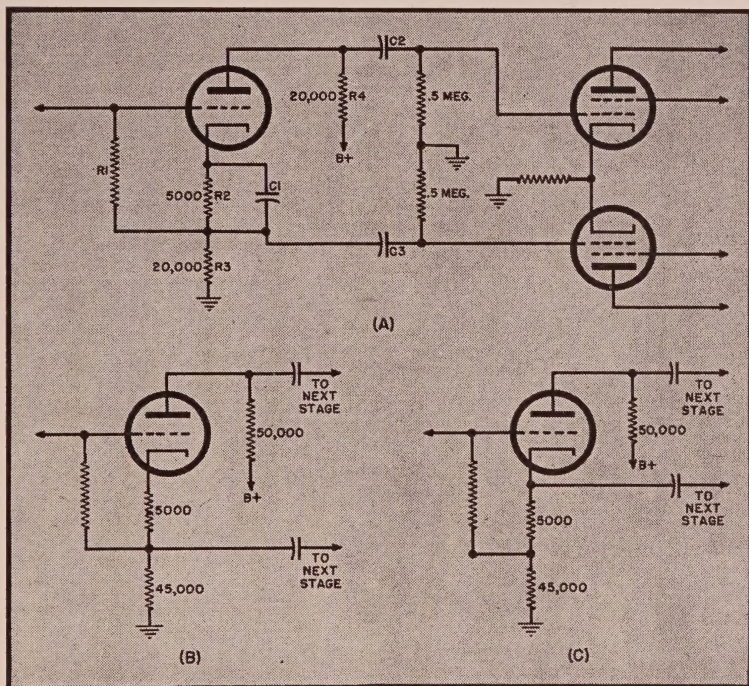


Fig. 5. Similar in operation to Fig. 4, with the exception that the 6J5 is now self-biased which will eliminate the addition of a bias voltage source.

current in the other resistor. The voltage drop across the resistors will be similar regardless of the condition of the tube and the phase inversion process will go on unaffected by any change in the voltages. As the circuit is the cathode follower type, considerable degeneration is present which tends to reduce distortion. Some method must be provided for obtaining bias for the tube, however, and the output of the circuit is very low—1.8 times the input voltage for resistor values of twenty thousand ohms and this rises to about 3 with the higher values of resistors. This small amount of voltage is usually insufficient except for the smaller tubes such as the 25L6, 7A5, and other tubes which require less than 7 or 8 volts driving power for full output. The circuit can be utilized, however, to drive push-pull triode driver tubes with very good results and, because of the balance and low distortion, it is highly recommended for this type circuit, if some external bias voltage is available.

In Fig. 5, this circuit has been modified to provide self bias. Fig. 5A shows the basic circuit as it was first used. Cathode resistor R_2 is heavily bypassed by C_1 and the grid return resistor R_1 is connected to the junction of R_2 and R_3 , where the next stage audio voltage is also taken off. Because R_2 is heavily bypassed, very little audio voltage is developed across it and, therefore, no degeneration takes place. This accounts for the high gain of the circuit. Theoretically, this circuit is not so good for phase inversion because of the stray capacities that are across R_3 , i.e., the output wiring capacities of the preceding stage, which include coupling and decoupling condensers and tube output capacity. These capacities, it seems, would seriously affect the balance on high frequencies but they seem to affect it very little in practice.

In Fig. 5B, this basic circuit has been altered again. This time the total resistance of both plate and cathode resistors has been raised to fifty

thousand ohms. The cathode condenser has been eliminated with the result that a small amount of degeneration is allowed. This degeneration lowers the gain of the tube with the result that the gains are similar to that obtained in the basic circuit, shown in Fig. 4. The values shown, when used with a 37 or 6J5 tube, give adequate voltage to more than drive a pair of 42's or 6F6's to full output of ten watts. In the two previous circuits (Figs. 4 and 5A) the value of R_2 was the same as R_3 in Fig. 4, and R_3 the same as R_4 in Fig. 5A, with the result that the added value of R_2 (Fig. 5A) caused an unbalance in the circuit.

A method of getting around this unnecessary unbalance of resistance, as well as avoiding the effects of stray capacities across R_3 , is shown in Fig. 5C. Here, the 50,000 ohm resistor is used in the plate circuit as before. R_2 is made 5,000 ohms and R_3 is 45,000 ohms. The audio voltage for the next stage is then taken off the cathode of the tube. Much better fidelity and balance is obtained.

Although a great many assortments of resistor values may be used in these foregoing circuits, a plate resistor value of 50,000 ohms seems to give the best results of any tried. This value gives a wide frequency response, the high frequency cut-off point is well above the audio range and the low frequency response is excellent. Because the value is high enough to place it well above the plate resistance value of any of the common triodes that may be used, the circuit conditions are ideal for class-A operation.

In Fig. 6, we have the basic circuit used in most commercial sound systems. A dual triode, such as a 6SC7, 6SN7, 6C8, or 6N7, is used for the inverter tube. The input voltage applied to the first grid of the 6SC7 is amplified and applied to the grid of the next stage across resistors R_4 and R_5 . The ratio of these resistors determines the grid voltage to the second section of the inverter tube and is

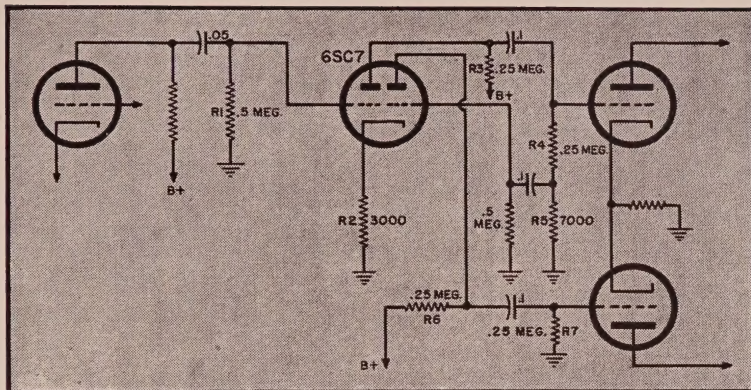


Fig. 6. Basic circuit used extensively in commercial sound systems.

equal to the output voltage of the first section, divided by the input voltage. Since the gain of this circuit, using a 6SC7, is 36, the ratio of R_3 to the total value of R_4 plus R_5 will be 36 and, in this case, the values of resistors are 250,000 ohms for R_4 and 7,000 ohms for R_5 which gives us a voltage across R_5 which is approximately $1/36$ of the output voltage or, to be exact, it is equal to $7,000/257,000$ of the out-

put voltage and this is also approximately equal to the voltage on the grid of the first section. Since the plate resistors R_3 and R_6 are equal, as are the next stage grid resistors, the voltages applied to the next stage grids are equal in magnitude and 180° out of phase.

Because of the high gain, the stage is very sensitive. The input voltage must be kept well below two volts to

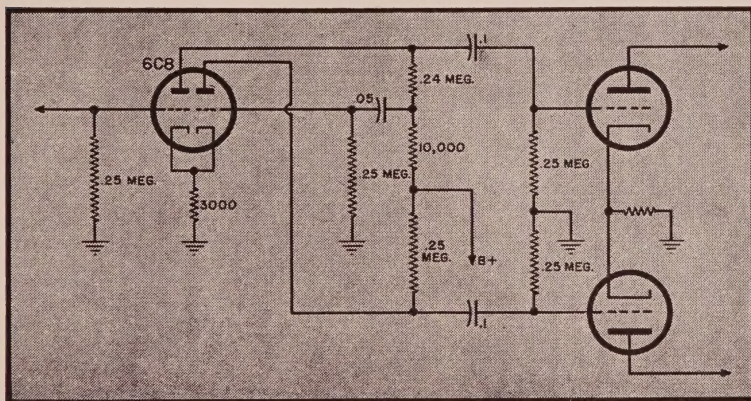


Fig. 7. A dual triode is used as an inverter tube. Like Fig. 6, no transformers are needed in its operation. The 6C8 is considered a good inverter tube.

avoid complete plate current cutoff with this particular tube. Any of the tubes mentioned may be used in this circuit. However, the others are less sensitive and, unless the voltage divider is adjusted, the balance will be affected. The balance of the two sections of the tube also affects the balance of the following stage. With the coupling condensers shown, the amplifier is rather "bassy" and, for better response, smaller condensers could be used. The high-frequency cutoff, however, is rather high, as in the case of all triodes.

In Fig. 7, we have a similar circuit. In this case we use a 6C8 inverter and operation is essentially the same. The tubes used in the previous circuit may well be used in this one and the choice of tubes will depend largely upon the necessary output voltage. The 6C8 or 6F8 have a top cap connection, while the others are single ended. The 6F8 is essentially two 6J5's in one envelope and is a very good inverter tube where low gain is desirable.

The proper choice of resistors here is made in the same manner as in Fig. 6. Although the values in the diagram

should be 240,000 ohms and 10,000 ohms respectively, we make the plate resistor 250,000 ohms as that value is standard. When designing inverters, it is best to go over the resistor stock and choose a value which is as close to the correct value as is possible. Since a tolerance of ten per cent is almost always allowable without serious unbalance, in a resistor of this size, twenty thousand ohms does not affect the operation very much. The circuit has the definite advantage over that of Fig. 6 that it avoids the effects of coupling condenser and the input capacity of the following tubes, as the inverter grid voltage is taken off the driver tube plate circuit.

In Fig. 8, we have a modified arrangement of Fig. 6, which compensates for a part of the unbalance that might otherwise occur. The modification consists of breaking the 7,000 ohm voltage divider into two 3,500 ohm resistors, R_2 and R_5 . Another 3,500 ohm resistor, R_3 , is placed in the grid return of VT_2 . Thus, the total grid voltage for VT_1 is formed across points A and B and the total grid voltage for VT_2 is formed across points B and C but each of these voltages is opposed

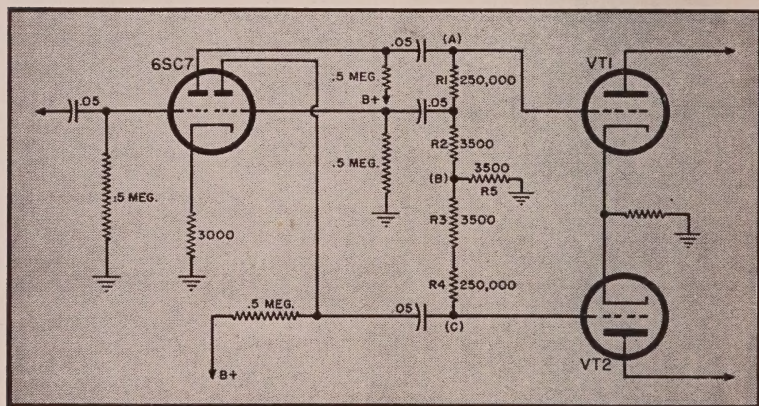


Fig. 8. Modified arrangement of Fig. 6. This circuit compensates for part of the unbalance that might otherwise occur.

by a bucking voltage that is formed across R_5 . This occurs because the signal voltages from each grid return circuit must pass through R_5 . Therefore, when considering the positive half cycle of the signal voltage, it is necessary to realize that the negative half cycle is being formed across R_5 as well. This, then, results in a balancing action because any difference in output voltage from one half of the phase inverter will be counterbalanced by an increase or decrease, as the case may be, of the opposing voltage from the other half of the inverter. Thus, a degree of automatic balancing takes place which will compensate for small voltage differences in the output voltage of the phase inverter. The circuit is slightly degenerative, reducing the gain slightly, but improved performance compensates for the loss in driving power and distortion in the output stage is reduced sufficiently so that the amplifier may be run wide open to make up the difference in driving power.

in which two resistance coupled triode driver tubes were used, operating from a pair of similar tubes, and the balancing action was very good, even when not used with a phase inverter-driver. In that amplifier, it was necessary to use a 6SC7 inverter driving a pair of 6C5's which in turn were used to drive a pair of 6J5's in class-A and these were transformer coupled to four 6L6G's, class-AB₂. The balancing circuit was used in the 6J5 grid return circuit since a more suitable resistor network presented itself.

In Fig. 9, we have a circuit where the phase inversion takes place in the second detector stage of the receiver. Two .1 megohm resistors are connected across the audio output of the second detector with their common tap grounded. The effect is essentially the same as a center tapped transformer, the demodulated output of the second detector dividing itself equally across these resistors. Two condensers C_1 and C_2 having a value of

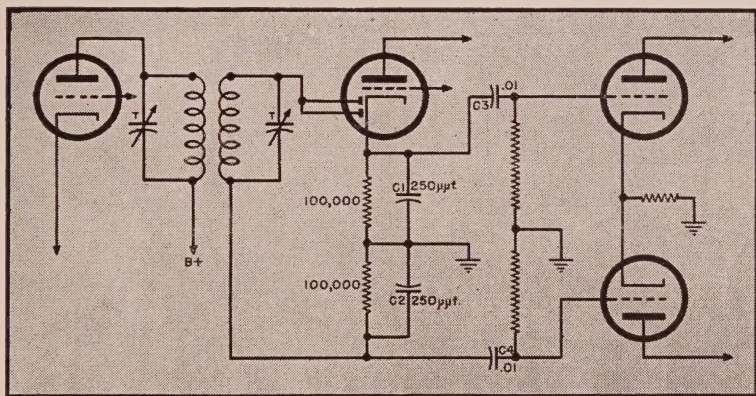


Fig. 9. Circuit diagram of a phase inverter which is somewhat unusual. Phase inversion takes place in the second detector stage of receiver.

This circuit is applicable not only to dual triodes but also single triodes operating in similar circuits and, not long ago, it was tried in an amplifier

250 $\mu\text{fd.}$ are used as r.f. filter condensers to reduce the r.f. potential left in the demodulated second detector output. Coupling condensers

C_3 and C_4 may be of any value, .01 μ fd. being the value generally used.

This circuit, while of low output, has the advantage of perfect balance since the output is not dependent on the tube characteristics. The output, however, is so low that it cannot be utilized to drive a power stage. However, it could be used with tubes such as 6J5's to provide driving power for a high power amplifier. The output would then be sufficient to drive a pair of 6F6's to full output or it could drive 6L6's to about fifteen or eighteen watts if the receiver over-all gain were high enough to provide approximately two volts at the driver grids.

This about covers the assortment of phase inverters that are very useful at present. A few facts to remember about phase inverters are, never bypass the cathode resistor unless specified. The system usually is necessarily designed in such a manner that the output would be highly distorted were it not for the degeneration that takes place when the cathode is left unbypassed. Other than for the bypass condenser, the inverter is usually designed like a regular class-A amplifier. Ordinarily, the resistor values used are the same as they would be in the case of an ordinary class-A amplifier stage and are split up accordingly in the voltage dividers. Remember, the audio voltage will divide itself across a resistor in the same manner d.c. voltage does. Whenever designing or servicing a phase inverter system, where two tubes are used or if a dual triode is used, make sure they both

have identical emissive characteristics or are as close to being identical as it is possible to get them.

Although a good tube tester and an ohmmeter is all the equipment that is necessary when designing and servicing phase inverters, a signal tracing unit such as a chanalyst is desirable, since it is possible to measure the actual balance of voltages. An oscilloscope, of course, can be used for the same purpose and with it, you can also observe the phase relationships of the voltages. The balance of the voltages is always dependent on the resistors, the values of the coupling condensers, and tube characteristics. As long as the resistor values are chosen correctly, the coupling condensers are identical and the tube characteristics are identical, the operation of the two sides of the amplifier will be identical. Distortion in a phase inverter can usually be traced to unbalance caused by one or more of those parts changing value enough to impair operation. The resistors have a tendency to change value as some of them have a rather high audio voltage across them and run rather hot.

The phase inverter is a handy system for the serviceman in these days of shortages, since one can be hooked up in the average shop in a few minutes. As the fidelity is high, the customer is well pleased and the serviceman can make a neat profit on a job that he otherwise would have to refuse because of unavailability of parts or tubes.

THE RADIO TRADING POST

(Continued from page 6)

TRADE—Swiss music box for teleplex, ac operated Instructograph or G-L model S sender. Also have tubes, speakers, meters, some cash. G. Samkofsky, 527 Bedford Ave., Brooklyn, N. Y.

WANTED—Drafting work design or development in electronics, electro-mechanical or mechanical fields. J. W. Bourke, 148 Winthrop St., Brooklyn 25, N. Y.

FOR SALE—Dietzgen slide rule, slightly used, 10" with leather case and instruction and practice booklets. \$2.00. Pvt. R. D. Luchi, Co. B, 4th Bn. S.C., Ft. Meade, Md.

FOR SALE—GE HM 185 and HM 187 television receiver. Complete set of Sickle IF transformers for television recvr. Alfred C. Denson, Rockville, Conn.

FOR SALE OR TRADE—In storage during the war practically new S-29 Hallicrafter Sky Traveller complete with extra set of new tubes, \$50.00, or will pay difference for F2 Leica camera. W6AT, 1420 El Miradero Ave., Glendale 1, Calif.

WANTED — Scarce tubes such as 50L6, 35L6, 35Z5, etc., at 40% off list. Specify types and quantity available. All letters answered. Spada Enterprises, 10 Lexington St., Wethersfield 9, Conn.

FOR SALE — Echophone EC-1. Have installed iron core IFs for greater sensitivity, set guaranteed perfect. Best offer gets it. Want 500 ma 5-20 hy choke. Wilbur L. Cornelius, 311 So. 4th St., Maquoketa, Iowa.

WANTED — Instruction book and tube charts for 770 Weston tube tester. C. H. C., 301 N. Market St., Mechanicsburg, Penna.

SELL OR SWAP—One each following tubes slightly used, 800, 801, 1616, 9002, 955, 2D21, 210 and 354. Interested in rec. tubes, power supply components, etc. R. H. Compton, 113 Locust Drive, Catonsville 28, Md.

TRADE—Meters, tubes, radio parts, tools, motors, elec. appliances, etc. for anything useful. Describe your goods fully. Roby's Swapmart, 820 E. 61 St., Chicago, Illinois.

FOR SALE — Webster automatic record changer, mod. 26. Mounted in portable leatherette case. Equipped with phonoscillator. Make offer. N. C. Stein, 2902 Colonial, Dallas 15, Texas.

WANTED—Radio News, January, 1940 or complete 1940 and 1941 sets. Homer H. Wagner, 647 Means Ave., Pittsburgh 2, Penna.

FOR SALE—Volt-ohmmeter, Million mod. VV, Abbott Transceiver, mod. DK-3. Send for list also other parts and meters. W9CFV, Jim Umstatt, 1318 N. Linden St., Bloomington, Ill.

WANTED—Hickok 532-P or C tube tester, Hickok 288x oscillator, Hickok 110 vac. tube voltmeter, Hickok 305 oscillograph, Weston 669 vtvm, Weston 776 oscillograph. Will pay cash, must be reasonable. J. Jones, 1653 No. Arlington Place, Milwaukee 2, Wis.

WANTED—Portable and ac-dc recvr., late model, new or in good condition. Cash paid. All letters answered. Louis Cherno, 1668 E. 13th St., Brooklyn 29, N. Y.

WANTED—All-wave sig. gen. Either a 1936 mod. 1231, 1232 Triplett, Burton-Webber 10, Clough-Bregle OC, or RCA Victor 97B. James R. Monsoos, 4837 Harriet Ave., So. Minneapolis 9, Minn.

WANTED—Oil burning space heater, state capacity, price. Have scarce tubes in cartons for trade. L. J. Brennan, 799 Silvercrest Ave., Akron 14, Ohio.

FOR SALE—Electric "Travel" iron \$5; heavy duty vegetable juicer \$25; footballs \$5; punching bags \$6; 6w ac amp. mike and speaker \$25. L. J. Brennan, 799 Silvercrest Ave., Akron 14, Ohio.

FOR SALE—Weston tube checker 777, 3 months old, like new, \$55, with oper. instructions. C. B. Davis, 1612 Hurt Building, Atlanta, Georgia.

FOR SALE—3 new Stancor power trans., P-6006, 700v. 120 ma; 5v at 3 amp.; 2 1/2v with center taps, \$4 each. Postpaid. Yen Radio Service Lab., Rockford, Mich.

TRADE OR SELL—Two-way inter-comm., oxide batt. charger, 6w PA system, transceiver vibrapak, 2 phono amp., port. sig. tracer, Tork time switch, elec. fan, 3 0-3 dc voltmeters. Need photo equipment. Stanley, 2748 Meade St., Detroit 12, Mich.

TRADE—Radio parts, tubes, books and cash for used power operated garden tractor or small sprayer. C. W. Hull, Rt. 1, Box 40B, Folsom, California.

WANTED—Low-priced communications receiver such as Hallicrafters S-20-R, and tube tester of well known make, latest model. State condition and price. John A. Makuta, W8TTF, Curtisville, Pa.

FOR SALE—4A WE oil damp pick-up with 200 ohm 9" ball bearing arm, T pad and scratch filter, condition A-1 in quality and appearance. \$12.00 complete. John J. Spankowitz, 239 No. 9th St., Allentown, Penna.

FOR SALE—All types radio tubes, list price, phono motors, 78 rpm, \$4.50; Signal Corps throat type mikes, 1" diam., weight 4 oz., \$0.98. A Valentino, Radio Service, 57-13 69 St., Maspeth, L. I., N. Y.

FOR SALE—Complete PA system, 24.5 w. output, uses 1 6SQ7, 2 6SC7, 1 6SJ7, 2 6L6, and 1 5T3. 2 phono inputs, 2 mike inputs, 1 radio input, 4 vol. controls, with phono top. 2 12" pm speakers, 1 mike and stand, cables, used 4 times. \$125. Andrew Valentino, 57-13 69 St., Maspeth, L. I., N. Y.

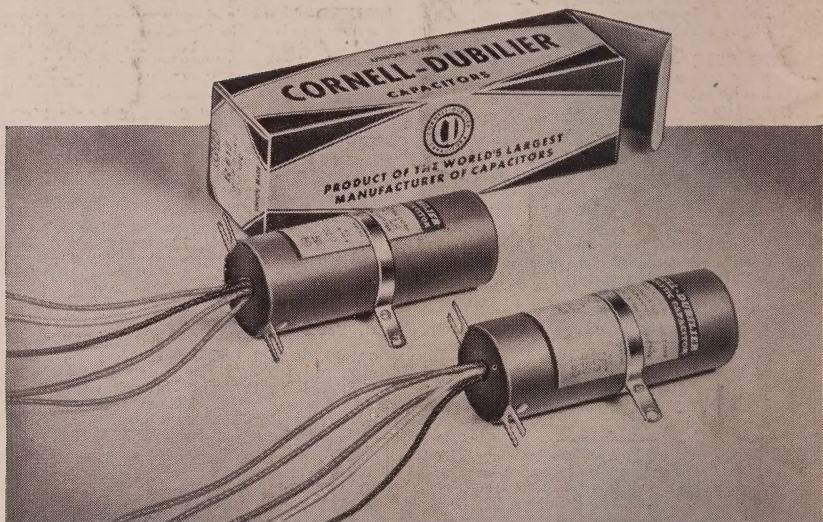
FOR SALE—Stewart Warner dyn. spkr., for 900 series; Victor dyn. spkr. for RE 45; power transf. for Crosley Jewel Box 804-60; Philco table mod. batt. set chassis 623 code 121; 1/2 hp 110-220 60c 1750 reconditioned. Make best offer. Howard Elec. Shop, 224 South Riverview drive, Kalamazoo 15, Michigan.

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